3. Goals

The mission, vision, and goals of the FreedomCAR and Vehicle Technologies (FCVT) Program, covered in this section, are consistent with the National Energy Policy, the DOE Strategic Plan, and the EERE Strategic Plan. This section also provides an examination of the energy, environmental, and economic drivers for the FCVT portfolio of technology R&D activities and a discussion of the FCVT implementation strategy.

NATIONAL ENERGY, ENVIRONMENTAL, AND ECONOMIC DRIVERS

The United States faces major challenges in meeting the ever-increasing demand for transportation goods and services while striving also to minimize adverse energy, environmental, and economic impacts. More than 97% of the fuel consumed by the U.S. transportation sector is petroleum-based, and this usage accounts for two-thirds of the nation's total oil consumption. Specific vehicle fuel efficiencies have improved steadily since the 1970s, but increases in population and per capita miles driven, as well as the increased use of sport utility vehicles rather than cars, have more than offset these gains; the overall average efficiency, miles per gallon, has declined over the last few years as a result of increased vehicle size. The outcome has been an overall increase in consumption of petroleum for transportation. With the demand for petroleum products growing at more than 1.6% per year, and domestic crude oil production declining by about 0.4% per year, the Energy Information Administration (EIA) predicts that the share of petroleum consumption met by net imports will rise to 70% by the year 2025. The EIA also forecasts that by 2010, 30% and by 2025, 38% of the oil traded on the international market will come from the Persian Gulf, a region characterized by continued political sensitivity.

In addition to a growing demand for petroleum in the United States, worldwide demand for petroleum has grown steadily during the 1900s. Globally, petroleum demand for 2025 is expected to reach 123 million barrels per day, compared with 77 million barrels per day in 2000, an annualized growth rate of about 2% per year. Rapid growth among developing nations means global competition for the world's petroleum. The potential for economic and environmental instability associated with petroleum consumption continues to grow, as indicated by the projected growth of worldwide vehicle registrations. In 2000, total motor vehicle registrations worldwide numbered 701 million. Between 2000 and 2050, motor vehicle registrations could easily grow from 700 million to 3 or 4 billion (Figure 12). Industrialized countries could

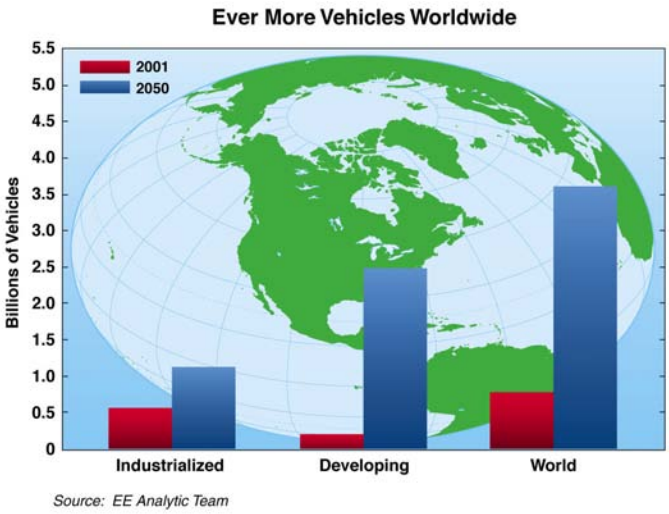

Figure 12. Motor vehicle registration growth.

experience a doubling of vehicle registrations, but most future growth in the vehicle market will come in developing countries.

The implication of rapid growth in petroleum demand coupled with declining oil resources is that we need to begin introducing more-efficient vehicles soon, if not now, to avoid consequences similar to the economic impacts of the oil shortages of the 1970s and subsequent price shocks generated by the actions of the Organization of the Petroleum Exporting Countries. Every major oil price shock of the last 30 years was followed by a recession, and every major recession was preceded by an oil shock. The total cost of our oil dependence since 1970 is estimated at $7 trillion (in 1998 dollars).[1] In addition to the economic costs, oil dependence imposes military costs (estimated by the General Accounting Office at $33 billion per year) and political costs, because the need to have access to oil potentially involves conflicts with other national objectives. (However, these calculations may be questionable because of the many complexities surrounding the issue.)

About 90 million Americans live in areas with poor air quality, according to the Environmental Protection Agency. The American Lung Association estimates that health problems due to air pollution cost Americans more than $50 billion annually. Automobile emissions are a key contributor to air pollution.

There is also continuing concern about poor air quality and levels of greenhouse gases. In October 1999, the U.S. Environmental Protection Agency reported that about 90 million Americans live in areas that do not meet the National Ambient Air Quality Standards. The American Lung Association estimated in 1988 that Americans spent $50 billion annually on health care to treat problems resulting from air pollution. (The Association is currently updating this estimate and has indicated that the cost today is considerably higher, not only because of rising health care costs but also because of dramatically improved understanding of the impacts particulate emissions have on the human body.) The concentration of carbon dioxide in the air is 25% higher than it was before industrialization, an increase that is directly related to increased energy use. Increases in atmospheric concentrations of greenhouse gases are likely to alter the earth's climate, although scientists do not agree on the timing and nature of potential climate changes or on the scope and severity of the problems associated with a changing climate.

Another issue is the increasing global market competition in the transportation sector. Other countries with automobile industries (most notably Japan and the European nations) have committed substantial public funds to support advanced automotive research in partnership with their domestic manufacturers. All indicators suggest a long-term commitment by these governments to the development and production of advanced vehicles for both the domestic and the

[1] David Green and Nataliya Tishchishyna, *Cost of Oil Dependence: A 2000 Update*, ORNL/TM-2000/152, Oak Ridge National Laboratory, March 2000.

export markets. The emerging economies of Asia, Latin America, and Eastern Europe, where much of the future growth in the automotive market is expected, are becoming a competitive challenge for the global automotive industry. U.S. industries must remain competitive in order to penetrate these markets as well as maintain and create domestic jobs. These markets are expected to be particularly receptive to cost-competitive advanced vehicles with high fuel economy and low emissions.

Automotive R&D is critical to the United States because of the energy, environmental, and economic drivers. Therefore the National Energy Policy, DOE's energy strategy, and EERE's energy strategy are all tightly intertwined to meet these challenges.

NATIONAL ENERGY POLICY

The DOE and EERE support the basic principles set forth by the National Energy Policy, more specifically, the second principle of three, which is stated as follows:

> *The Policy will advance new, environmentally friendly technologies to increase energy supplies and encourage cleaner, more efficient energy use.*

DOE MISSION AND GOAL

The DOE mission includes several elements; most notably, as stated in the DOE Strategic Plan, for the EERE and FCVT efforts, the mission includes these elements:

> *Advance the national, economic, and energy security of the United States and promote scientific and technological innovation in support of that mission.*

The DOE Strategic Plan has four strategic goals, and the most notable goal for FCVT efforts is to

> *Protect our national and economic security by promoting a diverse supply and delivery of reliable, affordable, and environmentally sound energy.*

EERE MISSION, VISION, AND STRATEGIC GOALS

In support of the DOE mission and goal, and as stated in the EERE Strategic Plan, the EERE mission is to

> *Strengthen America's energy security, environmental quality, and economic vitality through public-private partnerships that*

- Enhance energy efficiency and productivity;
- Bring clean, reliable, and affordable energy production and delivery technologies to the marketplace; and
- Make a difference in the everyday lives of Americans by enhancing their energy choices and their quality of life.

The EERE Vision, as stated in the EERE Strategic Plan, is

> *A prosperous future where energy is clean, abundant, reliable, and affordable.*

And, it continues, specifically applicable to the FCVT Program, an energy future where

> *... Our cars and trucks will be more efficient and will be powered by a variety of clean domestic fuels and technologies that free the U.S. from dependence on foreign supplies of energy.*

The FCVT Program most directly supports the general goal to "enhance energy security by developing technologies that foster a diverse supply of affordable and environmentally sound energy, improving energy efficiency, providing for reliable delivery of energy, exploring advanced technologies that make a fundamental change in our mix of energy options, and guarding against energy emergencies."

Goal 1 of the nine EERE strategic goals delineated in the EERE Strategic Plan provides the basis for the FCVT Program.

> *Goal 1. Dramatically Reduce, or Even End, Dependence on Foreign Oil.*

FCVT VISION

The vision for the FCVT Program is that, ultimately,

> *Transportation energy security will be achieved through a U.S. highway vehicle fleet of affordable, full-function cars and trucks that are free from petroleum dependence and harmful emissions without sacrificing mobility, safety, and vehicle choice*

FCVT MISSION AND GOALS

As set forth in the EERE Strategic Plan, the mission of the FCVT Program is to

> *Develop more energy-efficient and environmentally friendly highway transportation technologies that enable America to use less petroleum.*

With this mission, the general FCVT Program goal is to

> *Develop technologies that enable cars and trucks to become highly efficient, through improved power technologies and cleaner domestic fuels, and to be cost and performance competitive. Manufacturers and consumers will then use these technologies to help the nation reduce both energy use and greenhouse gas emissions, thus improving energy security by dramatically reducing dependence on foreign oil.*

The long-term aim is to develop "leapfrog" technologies that will provide Americans with greater freedom of mobility and energy security, with lower costs and lower impacts on the environment. To accomplish the mission, the FCVT Program includes promoting the development of fuel-efficient motor vehicles, researching options for using cleaner fuels, and implementing programs to improve

energy efficiency. In collaboration with industry, research entities, universities, state governments, and other federal agencies, the FCVT Program supports R&D of advanced vehicle technologies and fuels that could dramatically reduce, and eventually eliminate, the demand for petroleum, decrease emissions of criteria air pollutants and greenhouse gases, and enable the U.S. transportation industry to sustain a strong, competitive position in domestic and world markets. These collaborations facilitate the coordination of activities and attract cost sharing to provide leveraged benefits for the American taxpayer. The program focuses its technology development investments specifically on areas that would not be pursued by industry alone because of high risks and uncertain or long-term outcomes.

Program implementation includes research, development, demonstration, testing, technology validation, technology transfer, and education. Work is aimed at developing technologies that could achieve (1) significant improvements in vehicle fuel efficiency and (2) displacement of oil by other fuels that ultimately can be domestically produced in a clean and cost-competitive manner. It is focused on technologies to reduce oil use by highway vehicles such as cars, light trucks, and heavy vehicles (comprising medium and heavy trucks, and buses). Off-highway vehicles (such as vehicles used in construction, mining, and agriculture) and locomotives may benefit from this research because they use engines that are similar to those in heavy-duty trucks. As detailed in the Overview to this plan, the FCVT supports, and works through, three major government–industry endeavors with the following goals:

> *The long-term goal of the FreedomCAR and Fuel Partnership is to accelerate the development of the component and infrastructure technologies necessary to enable the full spectrum of light-duty passenger vehicle classes to operate completely free of petroleum and free of harmful emissions while sustaining the driving public's freedom of mobility and freedom of vehicle choice.*
>
> *To address the R&D needs of commercial vehicles, the ultimate goal of the 21st Century Truck Partnership is to dramatically improve the energy efficiency and safety of trucks and buses, while maintaining a dedicated concern for the environment. The vision of the Partnership is for our nation's trucks and buses to safely and cost-effectively move larger volumes of freight and greater numbers of passengers while emitting little or no pollution and dramatically reducing the dependence on foreign oil.*
>
> *The Presidential FreedomCAR and Hydrogen Fuel Initiative is to develop technologies for (1) fuel-efficient motor vehicles and trucks, (2) producing cleaner fuels, (3) implementing programs to improve energy efficiency, and (4) a hydrogen production and distribution infrastructure needed to power fuel cell vehicles and stationary fuel cells.*

The FCVT Program plays a prominent role in the FreedomCAR and Fuel Partnership by conducting R&D to achieve the nearer-term goals of the Partnership through continued development of advanced technologies that will dramatically reduce the fuel consumption and emissions of all petroleum-fueled, light-duty

personal vehicle classes. Achieving these goals is of paramount importance to providing the necessary technologies for hybrid fuel cell-electric vehicles and achieving the long-term goal. The FreedomCAR and Fuel partners have identified nine challenging high-level technical goals for government and industry R&D efforts. The FCVT Program has exclusive responsibility for four of these goals and shares one with the Hydrogen, Fuel Cells, and Infrastructure Technologies Program (cost estimate goals are assumed for mass-production levels of the particular component):

- Electric Propulsion Systems with a 15-year life capable of delivering at least 55 kW for 18 seconds and 30 kW continuous at a system cost of $12/kW peak.
- Internal Combustion Engine Powertrain Systems costing $30/kW, having a peak brake engine efficiency of 45%, that meet or exceed emissions standards.
- Electric Drivetrain Energy Storage with a 15-year life at 300 Wh with discharge power of 25 kW for 18 seconds and costing $20/kW.
- Material and Manufacturing Technologies for high-volume production vehicles that enable/support the simultaneous attainment of a 50% reduction in the weight of vehicle structures and subsystems, affordability, and increased use of recyclable/renewable materials.
- Internal Combustion Engine Powertrain Systems operating on hydrogen with a cost target of $45/kW by 2010 and $30/kW in 2015, having a peak brake engine efficiency of 45%, that meet or exceed emissions standards (shared responsibility).

Development of technologies to achieve these goals applies to purposes 1, 2, and 3 of the Presidential FreedomCAR and Hydrogen Fuel Initiative.

In addition to working on technologies for light-duty passenger vehicles, the FCVT Program addresses R&D of technologies for commercial vehicles through the 21st Century Truck Partnership. The FCVT Program has the responsibility for 21st Century Truck Partnership management and for conducting and supporting the R&D necessary to meet the Partnership goals. Specific technology goals have been defined in five critical areas that will reduce fuel usage and emissions while increasing heavy vehicle safety. The Partnership supports research, development and demonstration to enable achieving these goals with commercially viable products and systems (cost goals are assumed to be at mass-production levels of that particular component).

Engine Systems

- Develop and demonstrate an emissions-compliant engine system for Class 7–8 highway trucks that improves the engine system fuel efficiency by 20% (from approximately 42% thermal efficiency currently to 50%) by 2010.
- Research and develop technologies that will achieve a stretch thermal efficiency goal of 55% in prototype engine systems in 2012.
- Develop new diesel fuel formulation specifications, which include the use of renewables and other non-petroleum based blending agents, that enable achieving high-efficiency and low-emission goals while displacing petroleum fuels by 5% by 2010.

Heavy-Duty Hybrids

- Develop a drive unit that has 15 years of characteristic life and costs no more than $50/kW peak electric power rating by 2012.
- Develop an energy storage system with 15 years of characteristic life that costs no more than $25/kW peak electric power rating by 2012.
- Develop and demonstrate a heavy hybrid propulsion technology that achieves a 60% improvement in fuel economy, on a representative urban driving cycle, while meeting regulated emissions levels for 2007 and thereafter.

Parasitic Losses

- Reduce heavy truck parasitic losses (e.g., aerodynamics, ancillary systems) from 39% of engine output in 1998 to 24% in 2006.
- Reduce the weight of a tractor-trailer from 23,000 pounds in 2003 to 18,000 pounds in 2010 (a 22% reduction), thereby increasing heavy truck fuel efficiency.
- Develop and demonstrate advanced technology concepts that reduce the aerodynamic drag of a Class 8 highway tractor-trailer combination by 20% (from a current average drag coefficient of 0.625 to 0.5) by 2012.
- Develop and demonstrate technologies that reduce essential auxiliary loads by 50% (from current 20 horsepower to 10 horsepower) for Class 8 tractor-trailers by 2012.
- Develop and demonstrate lightweight material and manufacturing processes that lead to a 15 to 20% reduction in tare weight (for example, a 5000-lb weight reduction for Class 8 tractor-trailer combinations) by 2012.

Idle Reduction

- Develop and demonstrate a 5-kW, $200/kW, diesel-fueled internal combustion engine auxiliary power unit (APU) by 2007.
- Develop and demonstrate a fuel cell APU system in the 5- to 30-kW range, capable of operating on diesel fuel, at a delivered cost of $400/kW by 2012.
- Develop consistent electrical codes and standards that apply to both truck (onboard) and truck stop (stationary) electrification technologies, to enable the introduction of new idle reduction technologies.

Safety

- Contribute to reducing truck-related fatalities[2] by 50% and truck-related injuries by 20% by 2012, relative to 1996, through the development and implementation of technologies in crashworthiness and crash protection.
- Achieve occupant survivability for vehicle collisions at the front, rear, and sides for differential speeds of up to 35 mph between heavy vehicles and other typical light mid-size vehicles (weight <4000 lb).

[2] This goal includes the fatalities of drivers and passengers of other automobiles involved in accidents with heavy-duty trucks.

- Develop and implement advanced technologies for braking, rollover protection, visibility enhancement, and safety of tires needed to achieve the following performance for crash avoidance:

  Braking: One-third reduction in stopping distances at operational speeds.

  Roll-over: Maintain vehicle stability without exceeding static roll-over thresholds.

  Visibility: Full operator visibility (360°) with no blind spots anytime, anywhere, and on any side of the heavy vehicle for the operator, and increased on-road recognition of trucks by other vehicles.

The development of technologies to achieve the safety goals described is the responsibility of the Department of Transportation; however, the FCVT Program supports the development and validation of technologies to achieve all of the goals. The following priority goals have been determined through discussion with partners and through internal government deliberation (for example, between DOE and the Office of Management and Budget):

Heavy Vehicle Systems

Develop technologies that reduce parasitic energy losses, including losses from aerodynamic drag and ancillary systems, from 39% of total engine output in 1998 to 24% in 2006.

Hybrid Electric Propulsion

Reduce the production cost of a high-power 25-kW battery for use in light-duty vehicles from $3000 in 1998 to $500 in 2010, with an intermediate goal of $750 in 2006 that would enable cost-effective entry of hybrid vehicles. (This will be measured as the cost per 25-kW battery system, estimated for a production level of 100,000 battery systems per year.)

Advanced Combustion Engine R&D

Improve the efficiency of internal combustion engines from 30% (2002 baseline) to 43% by 2010 for light–duty applications and from 40% (2002 baseline) to 55% by 2012 for heavy-duty applications while meeting cost, durability, and emissions constraints, and while using an advanced fuel formulation that incorporates a non–petroleum-based blending agent to reduce petroleum dependence and enhance combustion efficiency.

Materials Technologies

Reduce the production cost of carbon fiber from $12 per pound in 1998 to $3 per pound in 2006. (Figures are based on production levels of at least 5 million pounds per year.)

Reduce the weight of an unloaded tractor-trailer combination from 23,000 pounds in 2003 to 18,000 pounds in 2010, a reduction in weight of 22%, thereby increasing heavy truck fuel efficiency.

These goals have been used to formulate performance measures to allow continual assessment of progress as delineated in Section 5, which covers management of this program. The FCVT Program is divided into sub-programs and key activities to parallel technology areas, as shown in Section 4; and each sub-program section gives a further breakout of technology-specific goals and technical targets necessary to achieve the goals, along with the necessary tasks and important milestones.